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A Review-Differentiating TV2 and TV3 Series Turbo Shaft Engines

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ABSTRACT

The paper embodies differences of TV2/TV3 engines. The Klimov initially called as Isotov TV2/TV3 gas turbine turbo shaft engines used in Helicopters. It is designed to develop power required for the rotation of the rotors and consists of different parts. The engines internal constructions are source of driving power where as the external parts are accessories like starter, fuel system, oil system, e.t.c. Their main differences are mainly in engine construction and performance. It is a wide scope to cover and get basic parameters in all engine series. There are limitations in the availability of description manuals for TV series engines. In addition to this it requires engines' detail practical knowledge acquired by experience on TV series engine operation including test bench, ground and flight tests. It is not recommended to refer all manuals to get a specific technical and operational data in maintenance workshop for beginners or junior technicians. The engine power operation is directly affected by the cyclic and collective pitch sticks as well as the engine itself. Differentiating Isotov TV2/TV3 engines greatly help operators, Engineers, trainers and technicians to easily understand the basic data of Klimov engines installed on Russian Mil helicopters.

Keywords: Turbo shaft engine, Klimov, engine performance, Isotov engines, engine construction

1. Introduction

The most common engine used by helicopters is turbo shaft engines. It is applicable in most helicopters, marine and auxiliary power units. The turbo shaft plays a great role in the aviation industry as well as for industrial power generation [1].

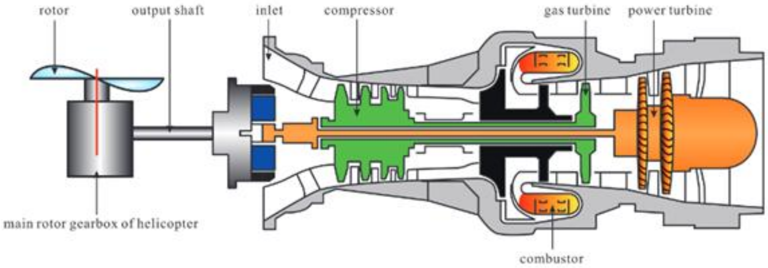

Fig.1-General Turbo shaft engine configuration [2]

The Figure above shows an internal view of a typical turbo shaft engine. Air is sucked and passed into engine inlet by means of a compressor. The compressor compresses the air to some temperature and low speed to facilitate smooth combustion. The compressor may have one to many stages of both centrifugal and axial compressors types.

This depends on the engine size, manufacturer and power output. Finally the compressed air is then sent through the combustor to burn with atomized fuels with raising the temperature of the air [1]. The TV2/TV3 series engine consists of different parts, components and systems. These are engine control system, engine starting system, inlet/outlet devices, engine cooling system, engine fuel system, engine oil system, engine fire fighting system, power transmission, main gearbox coupling, nacelles and cowling.

2. Literature Review

Turbo shaft engines used by Mil Russian helicopters are the Klimov TV2 and TV3 series engines.

2.1 Klimov TV2-117 series

The Klimov TV2-117 initially sometimes called as Isotov TV2-117 is a gas-turbine turbo shaft engine used in Russian helicopters. It was designed in the early of 1960s by the Isotov design bureau and later produced by Klimov production in 1997 [3].

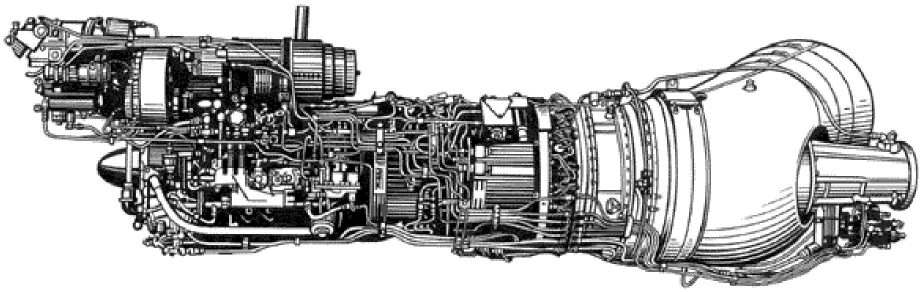

Fig. 2- The Klimov TV2-117 turbo shaft engine [4]

The TV2-117A is a turbo shaft engine with a free-turbine composed of two rotors namely the gas generator rotor in the front and the free power turbine at rear [5]. The TV2-117A engine features several improvements over the basic model. The modification is mainly on soft coatings in the compressor is substituted by tougher deposited coating on the steel parts of the stator.

Table 1 The main features in TV2 series engines [6, 7];

TV2-117AG engine	Carbon sealing applied in the second bearing support
TV2-117A engine	Soft coatings are applied in the compressor are substituted by tougher deposited coating on the steel parts of the stator;
TV2-117F engine	It is used for Mi-8FT helicopter and certified in Japan under the US airworthiness standards (FAR-33). It has emergency power which made it distinctive feature;
TV-117TG engine	It equipped with fuel controls that was designed to operate on liquefied propane, butane, gasoline, gas condensates, kerosene, diesel fuel (summer or winter fuels as well as any mixture thereof). The engine is designed for operation on Mi-8TG helicopters in remote areas of Siberia. It is also operational at Arctic, Antarctic and other regions with an extremely harsh climate.

2.2 Construction of Klimov TV2-117 series

The helicopter power plant is designed to develop power required for the rotation of the rotors and it consists of the following engine parts; Ten-stage axial flow, two-stage compressor turbine, combustors (Eight-chamber can-annular), two-stage power turbine, exhaust pipe an engine mount and attachment units.

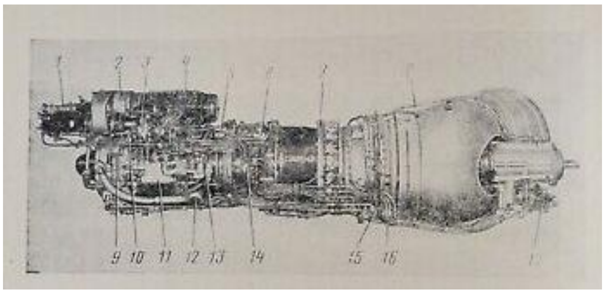

Fig. 3- Engine parts [8]

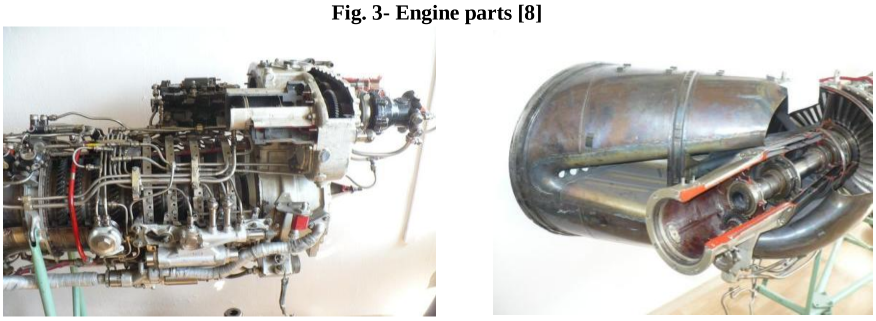

Fig. 4- Inlet part with engine fuel system (Left); Exhaust pipe and turbine output shaft (Right) [9]

Figure 5 below shows TV2-117A engine testing procedure and its final test results. First the starting torque is established at 100 Nm. The engine must be with the free turbine speed around 97 % in order to operate the engine for higher regimes [10].

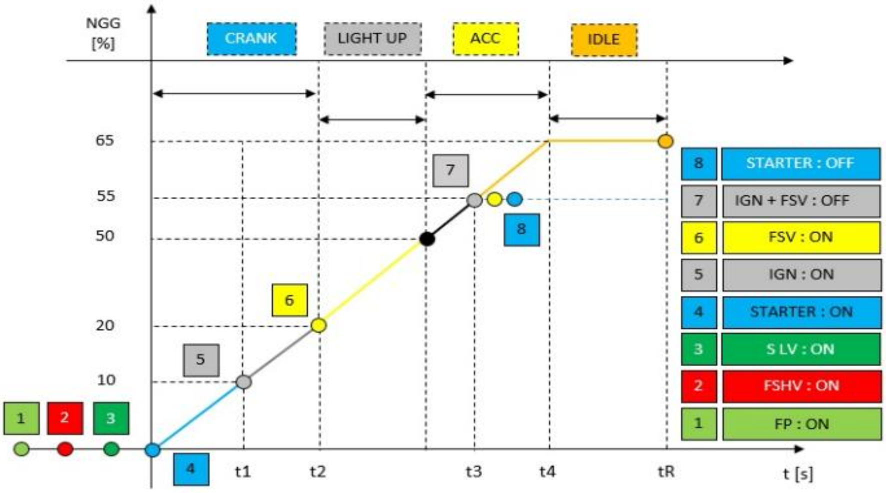

Fig. 5- TV2-117A engine start-up diagram

Table 2 Principal specifications of the TV2-117 engine [6, 11]

Specifications of TV2-117 engine	
Full thrust performance at (H= 0, V= 0, ISA + 15°C)	
Take- off power, hp	1500
specific fuel consumption, g/hp/hr	275
Cruising performance (H=0, V=0, ISA+15°C)	
power, hp	1000
specific fuel consumption, g/hp/hr	310
Dimensions, mm	
Length	2843
Width	550
Height	748
Weight, kg	334
Overall pressure ratio:	6.6:1 at 21,200 rpm
Air mass flow:	8.1 kg/s (1,070 lb/min)
Turbine inlet temperature	1,150 K (880 °C)
Specific fuel consumption :	0.606 lb/(hp·h) (0.369 kg/kWh)
Power-to-weight ratio:	2.06 hp/lb (3.39 kW/kg)

2.3 Klimov TV3-117 series

The TV3-117 engine is a turbo-shaft engine designed to drive the helicopter rotor and its auxiliary units. The engine is upgraded for a better performance requirement with a new model series called TV3. TV3-117 turbo shaft engine was developed in 1974. Later it was installed on 95% of all helicopters designed by Mil and Kamov Engineering Centre [12].

Fig. 6- The Klimov TV3-117 turbo shaft engine [12]

TV3-117 engines are the main power unit of Mi-8 / Mi-17 / Mi-171 / Mi-24 helicopters. There were a number of versions created for different types of helicopters. In the turbo-propeller version TV3-117VMA-SBM1 are even mounted on Antonov-140 aircraft. The power plants of these helicopters (except Mi-28) incorporate main gearboxes that were also developed by the Klimov Company such as VR-14, VR-24, VR-252 and VR-80 [12].

Table 3 Different engine features for TV3-117 turbo shaft engine [13].

TV3-117M engine	"M" stands for "marine" for Mi-14 helicopters incorporates special features to be used at sea.
TV3-117MT engine	"MT" stands for "modernized, transport" was designed for Mi-8MT/Mi-17 helicopters
TV3-117KM engine	"KM" means Kamov, marine was designed for Ka-27 helicopters;
TV3-117V engine	"V" stands for "high altitude" was designed for Mi-24 helicopters operated in the mountains.
TV3-117VK engine	"VK" stands for high altitude and is a model similar to the TV3-117B engine. It is adapted to Ka-27, Ka-29 and Ka-32 helicopters.
TV3-117VM engine	"VM" means high altitude, modernized engine with features of automatic switch to emergency power. It was designed for Mi-28 helicopters.
TV3-117VMA engine	"VMA" stands for high altitude, modernized of model "A" and was designed for Ka-50 helicopters. Export models are equipped with TV3-117VMAR engines (an extra «R» stands for "power") whose rated power and cruising power are similar to those of the TV3-117VKR engine;
TV3-117(A)	A turbojet engine for unmanned reconnaissance aircraft Reis and Reis-D developed by the Tupolev Design Bureau.

2.4 Construction of Klimov TV2-117 series

The main parts of TV3-117 engines are 12 Stage Compressor (1), coupling twin shaft connecting two stage turbine with compressor (2), combustion chamber (3), two-stage turbine (4), free turbine (5), exhaust pipe (6), shaft from free turbine to reducer (7) as shown in the figure below..

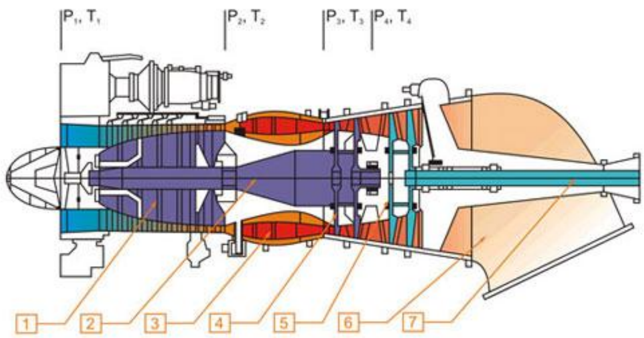

Fig 7- Schematic section of TV3-117 engine [12]

Behind the axial inlet device, we find a 12-stage axial compressor which compresses air for combustion. After the combustion chamber there is a two-stage compressor turbine and free turbine.

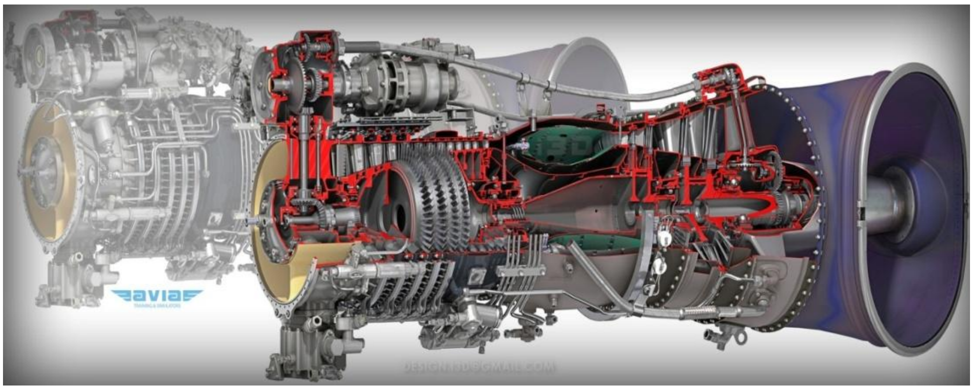

Fig. 8- Internal parts of TV3-117 turbo shaft engine [14]

Both engines on the helicopter work independently and can be shut down separately. The engine is started by an APU (auxiliary power unit) which is connected to the air starter turbine by hose. The starter turns the engine compressor on and at the specified speed the fuel ignites. After some operating regime, the starter is disconnected and the engine is already able to accelerate and maintain idle speed.

Fig. 9- TV3-117. A two-stage turbine driving a compressor and a free turbine driving a rotor and aggregates [12]

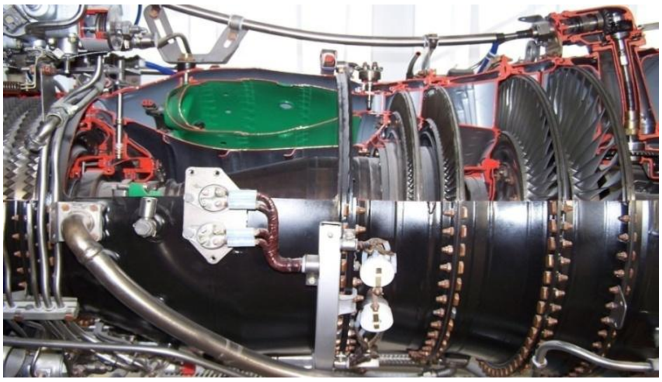

Fig. 10- Section through the engine, the combustion chamber and turbine driving the turbocharger and the free turbine are visible [12]

Oil system of aircraft engines are used for cooling and lubricating. The engine rotating parts run at high speeds with high temperatures. The main purpose of oil system is to ensure temperature control of individual engine to lubricate individual parts. The oil prevents corrosion and ensures that all lubrication points in the engine are vented. The fuel system is used to supply and regulation fuel to the combustion chamber in all modes of engine operation. The TV2-117 engines are started by a battery where as TV3-117 engine is started initially by air starter AI-9V which generated pressurized and high speed air to drive the engine.

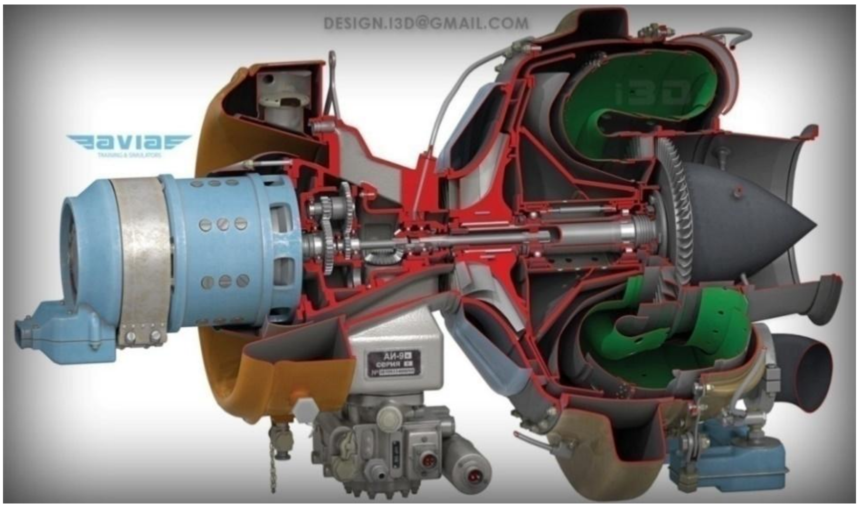

Fig. 11- AI-9V airstarter [14]

Fig. 12- The inlet (compressor) section [15]

Table 4 Specifications of the TV2-117 engine [16]

TV3-117 versions (OEI)	TV3-117VM	TV3-117VMA
Emergency performance (H=0, V=0, ISA+15^0C):		
power, hp	2200	2400
Takeoff performance		
power (ISA+25/15^0C), hp	2000	2200
specific fuel consumption, g/hp/hr	220	215
Cruising performance (H=0, V=0, ISA+15°C)		
power, hp	1500	1500
Dimensions, mm:		
Length	2055	2055
Width	660	660
Height	728	728
Weight, kg	295	295

Based on power plant system parts, we can differentiate roughly the major components (equipments) in the different Mil helicopters. This paper work only stresses some systems and components of the power plant.

3. Result and Summaries for Engine Differences

The helicopter power plant is designed to develop power required for the rotation of the rotors and it consists of the different engine parts. Based on these power plant components, we can differentiate roughly the major components (equipments) in different Mil helicopters. It covers their purpose, construction, location and data (parameter) related to the respective helicopters. The engine systems included in this study are;

- An engine
- An engine mount and attachment units
- An engine control system
- An engine starting system
- An inlet and outlet devices
- An engine cooling system
- Nacelles and cowling
- Fuel system
- Oil system
- Fire fighting system
- Power transmission and main gearbox

3.1 Engine TV-series general data [16,17,18,19,20,21,22]

Table 5 TV2/TV3 engine differences

Parameter	**Data**	**Remark**
Designation	Mi-8………TV2-117A Mi-17……..TV3-117MT Mi-24……..TV3-117A Mi-35……..TV3-117B	The RH & LH engines of the power plant are interchangeable, subject to turning the exhaust stack.

Type	Mi-8………Turbo-shaft free turbine Mi-17……..Turbo-shaft free turbine Mi-24……..Turbo-shaft free turbine Mi-35……..Turbo-shaft free turbine	Turbo-shaft engine is free turbine type
Flight speed	Mi-8……….From 0 – 250Km/hr Mi-17……...From 0 – 250Km/hr Mi-24……...From 0 – 350Km/hr Mi-35……...From 0 – 350Km/hr	
Flight altitude	Mi-8……….From 0 – 5000m Mi-17……...From 0 – 5000m Mi-24……...From 0 – 5000m Mi-35……...From 0 – 5000m	Engine starting is ensured up to 4000m
Take off power	Mi-8………………...1500hp Mi-17……………….2225(2200) hp Mi-24……….........2200 h Mi-35………………2100 hp	
Engine dry weight	Mi-8………………..330 kg $^{+2\%}$ max. Mi-17………………$285^{\pm5.7}$ kg Mi-24………………$285^{\pm5.7}$ kg Mi-35………………$285^{\pm5.7}$kg	**Note:** The engine dry mass does not include the mass of the following engine accessories: - Fuel filter along with piping - Gas generator tacho generator - Oil pressure pick up - Oil temperature sensor - Thermocouple harness
Engine length with accessories and exhaust stack	Mi-8………………..2843mm Mi-17………………2055mm Mi-24………………2055mm Mi-35………………2055mm	
Engine width with accessories and exhaust stack	Mi-8………………..550 mm Mi-17………………650 mm Mi-24………………650 mm Mi-35………………650 mm	
Engine width with accessories and exhaust stack	Mi-8………………..748 mm Mi-17………………728 mm Mi-24………………728 mm Mi-35………………728 mm	

3.2 Compressor related data [16,17,18,19,20,21,22]

Table 6 Compressor differences

Parameter	**Data**	**Remark**
Sense of rotation (looking FWD)	Mi-8………………..CCW Mi-17………………CCW Mi-24………………CCW Mi-35………………CCW	Compressor rotor. The compressor rotor is of drum-and-disc type
Compressor rotor rated rpm	Mi-8……………….12000rpm Mi-17……………...19500rpm Mi-24……………...19500rpm Mi-35……………...19537.5rpm	
Compressor-Turbine rotor (Gas generator rotor)	Mi-8………………CCW Mi-17……………..CCW Mi-24……………..CCW Mi-35……………..CCW	It is axial double stage rotor or known as n_{gg} rotor
Compressor turbine inlet gas temperature	Mi-8……….........850 max Mi-17……………..$990C^0$ Mi-24……………..$990C^0$ Mi-35……………..$990C^0$	About the compressor turbine -It is of two-stage axial-flow type. - It serves to rotate the compressor & the engine accessories. Parts - Turbine rotor (it consists of rotor shaft, two blade wheels, rotor rear journal, Labyrinth seal, covering disk & their fastening parts) - Nozzle diaphragm assemblies (1st stage NDA
Compressor turbine outlet gas temperature	Mi-8………………600 C^0 Mi-17……………..$640C^0$ Mi-24……………..$640C^0$ Mi-35……………..$640C^0$	
Compressor turbine axial speed	Mi-8……………..150m/s	

of inlet gases	Mi-17……………160m/s Mi-24……………160m/s Mi-35……………160m/s	& 2nd stage NDA) - Rotor bearing assemblies (3rd BA)
Compressor turbine axial speed of outlet gases	Mi-8……………...146 m/s Mi-17…………….158m/s Mi-24…………….158m/s Mi-35…………….158m/s	

3.3 Turbine related data [16,17,18,19,20,21,22]

Table 7 Turbine difference

Parameter	Data	Remark
Free turbine rotor	Mi-8………………..CCW Mi-17………………CCW Mi-24………………CCW Mi-35………………CCW	Rotation is when looking FWD
Free turbine type	Mi-8………axial double stage Mi-17……..axial double stage Mi-24……..axial double stage Mi-35……..axial double stage	Note: • FTS are void of kinematical linkage. • FT is sometimes called as power turbine. • It serves to transmit power to the main rotor, tail rotor & accessories via gearbox. Parts • Rotor shaft • Two bladed wheels • Labyrinth seals & • Fastening parts
Free turbine rated rpm	Mi-8………1200rpm Mi-17……..1500rpm Mi-24……..1500rpm Mi-35……..1500rpm	
Maximum temperature of inlet gases	Mi-8………600 ^{o}C Mi-17……..640 ^{o}C Mi-24……..640 ^{o}C Mi-35……..640 ^{o}C	Free turbine parameter
Temperature of outlet gases	Mi-8………400 ^{o}C Mi-17……..440 ^{o}C Mi-24……..440 ^{o}C Mi-35……..440 ^{o}C	Free turbine parameter
Turbine pressure reduction	Mi-8………2.0 Mi-17……..2.4 Mi-24……..2.4 Mi-35……..2.4	Free turbine parameter
Turbine efficiency	Mi-8………0.88 Mi-17……..0.9 Mi-24……..0.9 Mi-35……..0.9	Free turbine parameter

3.4 Compressor design [16,17,18,19,20,21,22]

Table 8 Compressor design differences

Parameter	Data	Remark
Compressor rotor type	Mi-8……………...axial type Mi-17…………… axial type Mi-24…………… axial type Mi-35…………… axial type	

Number of stages	Mi-8……………..10 Mi-17……………12 Mi-24……………12 Mi-35……………12	It is before and after compressor during takeoff mode i.e at H=0 and V=0
The rate of air pressure	Mi-8……………..1-7 Mi-17……………1-9.55 Mi-24……………1-9.55 Mi-35……………1-9.55	
Air consumption	Mi-8…………….TBD Mi-17……………8.75 Kg/s Mi-24……………8.75 Kg/s Mi-35……………8.75 Kg/s	It is at sea level and stand still i.e at H=0 and V=0
Temperature of air behind the compressor	Mi-8……………..372 ^{o}C max Mi-17……………335 ^{o}C Mi-24……………335 ^{o}C Mi-35……………335 ^{o}C	
Axial speed of air at compressor inlet	Mi-8…………….TBD Mi-17…………...112 m/s Mi-24…………...112 m/s Mi-35…………...112 m/s	
Efficiency of compressor	Mi-8…………….TBD Mi-17…………...0.855 m/s Mi-24…………...0.855 m/s Mi-35…………...0.855 m/s	
Compressor pressure ratio	Mi-8……………9.45max Mi-17…………..9.45 Mi-24…………..9.45 Mi-35…………..9.45	
Compressor design features	Mi-8……… Automatically controlled VGV of the IGV assembly.The1st, 2nd&3rd stage stator assemblies, as well as automatically controlled air blow off valves. Mi-17/Mi-24/Mi-35……..Have the same design except 4th stage stator assemblies	For Mi-17/Mi-24/Mi-35……… Automatically controlled variable guide vanes of the IGVassembly.The1st, 2nd, 3rd and 4thstage stator assemblies, as well as automatically controlled air blow off valves.
IGV and stator assembly vane angles	Mi-8………..30º to 0º Mi-17………$27^{o+1.5^o}$ to $-3^{o\pm0.5^o}$ Mi-24………$27^{o+1.5^o}$ to $-3^{o\pm0.5^o}$ Mi-35………$27^{o+1.5^o}$ to $-6.5^{o\pm0.5^o}$	It is according to the hydraulic actuator dial reading Note: A/. The range shows closing to opening (upper to lower stop) according to compressor VIGV and VGV setting angle (setting dial) B/. The turning is carried out automatically in the range from Ngg=80% to Ngg=100%
Number of air blow off valves	Mi-8……………2 Mi-17…………..2 Mi-24…………..2 Mi-35…………..2	Note : A/ For TB3 engines two valves bleeding air from 7thstage B/ After 7thstage the air is of high temperature and it is discharged in to the atmosphere. C/ A certain amount of air is diverted from compressor stage VII of each engine. This is used by the helicopter systems. Compressor parts - Rotor - Casings - Stator - Two bleed valves - Two rotor supports
Air bleed point	Mi-8……………..Downstream 6thstage Mi-17……………From stage 7 or 12 of compressor Mi-24……………After stage 7 Mi-35……………After stage 7	
Air blow off valve closing rpm	Mi-8……………$53^{\pm30}$ % Mi-17…………..TBD Mi-24…………..TBD Mi-35…………..TBD	

Minimum compressor rotor cost down time	Mi-8……………40 mn Mi-17…………..50 mn Mi-24…………..50 mn Mi-35…………..50 mn	Compressor rotor at start
Air bleed point	Mi-8……………downstream 8^{th} stage Mi-17…………..after 7^{th}stage Mi-24…………..after 7^{th}stage Mi-35…………..after 7^{th}stage	

3.5 Combustion Chamber [16,17,18,19,20,21,22]

Table 9 Combustion chamber differences

Parameter	**Data**	**Remark**
Combustion chamber type	Mi-8……..Annular with 8 fuel burners (nozzles) Mi-17/24/35…….Annular with 12 fuel burners	Annular type
Quantity of fuel manifolds	Mi-8……………..2 Mi-17……………2 Mi-24……………2 Mi-35……………2	Parts: Diffuser outer casing Diffuser inner casing Flame tube Fuel manifold Fuel nozzles Ignition plug Note: The fuel nozzles are of duplex and centrifugal type
Quantity of ignition plug	Mi-8……………..2 Mi-17……………2 Mi-24……………2 Mi-35……………2	
Inlet temperature	Mi-8…………….TBD Mi-17……………335 °C Mi-24……………335 °C Mi-35……………335 °C	
Out let temperature	Mi-8…………….TBD Mi-17……………990 °C Mi-24……………990 °C Mi-35……………990 °C	
Maximum temperature	Mi-8…………….TBD Mi-17……………2300 °C Mi-24……………2300 °C Mi-35……………2300 °C	

3.6 Exhaust system [16,17,18,19,20,21,22]

Table 10. Exhaust system differences

Parameter	**Data**	**Remark**
Exhaust system design	Mi-8……….Fixed area with exhaust pipe arranged at 60° relative to the engine axis Mi-17……..FAE arranged to 60° Mi-24……..FAE arranged to 60° Mi-35……..FAE arranged to angles between 75° & 105° relative to the horizontal plane	FAE-Fixed Area Exhaust
Maximum temperature	Mi-8……………..1500 °C Mi-17……………2300 °C Mi-24……………2300 °C Mi-35……………2300 °C	**Parts:** Diffuser outer casing Diffuser inner casing Flame tube Fuel manifold Fuel nozzles Ignition plug Note: The fuel nozzles are of duplex and centrifugal type

3.7 Permissible time of engine operation during overhaul periods in percent to total service life [16, 17, 18, 19, 20, 21, 22]

Table 11. Permissible time of engine operation

Parameter	Data	Remark
At takeoff power	Mi-8……………..1% Mi-17……………1% Mi-24……………1% Mi-35……………1%	Note: - Characterized by maximum permissible speed of turbo compressor - IR-117 indicator is above mark "**H"** - Twist grip fully up & collective pitch up most (15^0)
At limited takeoff	Mi-8……………..5% Mi-17……………5% Mi-24……………5% Mi-35……………5%	Note: A/ 5% includes 1% of the T.O. power B/ Limited T.O. is when there is no armament, full crew and limited fuel Qty C/ Limited take off is always less than take off power D/ T.O. =full fuel + armament + full crew E/ when Ngg=100%, Nmr=95.4% F/ Ngg=100% is equivalent to Nft=
At max continuous power	Mi-8……………..40% Mi-17……………40% Mi-24……………40% Mi-35……………40%	Note: - IR-117A indicates above "**K"** - Twist grip fully right correction & collective pitch up
At cruising power	Mi-8…………unlimited	
At cruise II power	Mi-17………unlimited Mi-24………unlimited Mi-35………unlimited	Note: - It is obtained by optimum power setting (with less fuel) - It is obtained by turning the twist grip CW and increasing the collective pitch to the value at which IR-117 EPR indicator is below the value of "K". ***ИР-117A engine pressure ratio (EPR) indicator
At cruise I power	Mi-17………unlimited Mi-24………unlimited Mi-35………unlimited	
At idle power	Mi-8……………..TBD Mi-17……………20 mn Mi-24……………20 mn Mi-35……………20 mn	Note: - It is selected by twisting the twist grip CCW and pushing the collective pitch fully down ward.

3.8 Engine ground acceleration [16,17,18,19,20,21,22]

Table 12. Engine ground acceleration differences

Parameter	Data	Remark
From start button depressed up to idle power	Mi-8…………..60secs Mi-17…………60secs Mi-24…………60secs Mi-35…………60secs	
From idle to T.O. power	Mi-8…………15 secs Mi-17…………9 secs Mi-24…………9 secs Mi-35…………9 secs	

From cruise to T.O. power	Mi-8…………..4 secs Mi-17…………4 secs Mi-24…………4 secs Mi-35…………4 secs	Note: Max. Continuous power = Nominal = Right correction. They are similar terminologies
From idle to right correction	Mi-8…………..3 to 6 secs Mi-17…………3 to 6 secs Mi-24…………3 to 6 secs Mi-35…………3 to 6 secs	
From start to takeoff	Mi-8…………..3 secs Mi-17…………5 secs Mi-24…………5 secs Mi-35…………5 secs	

3.9 Maximum permissible time of engine continuous operation [16,17,18,19,20,21,22]

Table 13 Max permissible time of engine

Parameter	**Data**	**Remark**
At T.O. power & limited T.O.	Mi-8…………..60 mn Mi-17…………60 mn Mi-24…………60 mn Mi-35…………60 mn	Note: 60 mn is part of the 5% of the service life. From 15-30mn only two time is permitted in the service life (it is part of 5%), from 30-60mn it is permitted only once in the service life. After that the engine and main gear box are subjected replacement
At max continuous power	Mi-8…………..60 mn Mi-17…………60 mn Mi-24…………60 mn Mi-35…………60 mn	
At cruising power	*For TV3-117 engine* *-At cruise II* Mi-17…………unlimited Mi-24…………unlimited Mi-35…………unlimited *-At cruise I* Mi-17…………unlimited Mi-24…………unlimited Mi-35…………unlimited	Note: There is no **cruise I I and I** power in Mi-8 helicopter instead there is cruise power only. . For Mi-8…………..unlimited
At idle power	Mi-8…………..20 mn Mi-17…………20 mn Mi-24…………20 mn Mi-35…………20 mn	Note: The number denotes that; **A/** we should not operate the engine in the idle power more than **20 mn** **B/** the idle power is not recorded on the record sheet of flying hr
Permissible time of engine operation within the service life	Mi-8…………..2000 hrs Mi-17…………2000 hrs Mi-24…………2000 hrs Mi-35…………2000 hrs	

3.10 Maximum permissible Ngg rpm at all speeds, altitudes of flight and engine ground acceleration (Ngg, gas generator rotor rpm)[16,17,18,19,20,21,22]

Table 14 Max permissible of Ngg

Parameter	**Data**	**Remark**
At take off power	Mi-8…………..101% Mi-17…………101% Mi-24…………101% Mi-35…………101%	
At limited take off	Mi-8…………..- Mi-17…………105% Mi-24…………105% Mi-35…………105%	*** Fluctuation of Ngg of steady state power

At max continuous power	Mi-8…………..100% Mi-17…………98% Mi-24…………98% Mi-35…………98%	condition at max. Continuous and cruise I power is up to ±5%
At cruising power	Mi-8…………..96.5% *For TV3-117 engine* *-At cruise II* Mi-17…………96% Mi-24…………96% Mi-35…………96% *-At cruise I* Mi-17…………94% Mi-24…………94% Mi-35…………94%	
At idle power	Mi-8…………..64^{+2}% Mi-17…………73^{+6}% Mi-24…………73^{+6}% Mi-35…………73^{+6}%	Note: Fluctuation of Ngg at steady state power condition at cruise II and below is up to ±0.7%.

3.11 Turbine inlet temperature (TIT) at all speeds & altitude of flight [16,17,18,19,20,21,22]

Table 15 TIT differences

Parameter	**Data**	**Remark**
At take off power	Mi-8…………..880°C ,max Mi-17…………990°C ,max Mi-24…………990°C ,max Mi-35…………990°C ,max	Note: The range is 975˚C-990˚C for TB3 engines
At limited take off	Mi-8………….. - Mi-17…………999°C ,max Mi-24…………999°C ,max Mi-35…………999°C ,max	
At max continuous power	Mi-8…………..860°C ,max Mi-17…………955°C ,max Mi-24…………955°C ,max Mi-35…………955°C ,max	Note: The range is 900˚C-955˚C for TB3 engines
At cruising power	Mi-8…………..880°C ,max *For TV3-117 engine* *-At cruise II* Mi-17…………870°C ,max Mi-24…………870°C ,max Mi-35…………870°C ,max *-At cruise I* Mi-17…………910°C ,max Mi-24…………910°C ,max Mi-35…………910°C ,max	Note: The range is 870˚C-910˚C for TB3 engines Note: The range is 830˚C-870˚C for TB3 engine
At idle power	Mi-8…………..600°C Mi-17…………780°C ,min Mi-24…………780°C ,min Mi-35…………780°C ,min	Note: Max number of consecutive starting attempts is 5 to be followed by at least 15mn shut down for cooling.

3.12 Main rotor speed (Minimum permissible) [16,17,18,19,20,21,22]

Table 16 Main rotor speed difference

Parameter	**Data**	**Remark**
In transient conditions of flight (during 30 sec)	Mi-8…………..89% Mi-17…………88% Mi-24…………88% Mi-35…………88%	

In auto rotation with engine running (no time limitations)	Mi-8…………..TBD Mi-17…………88% Mi-24…………88% Mi-35…………88%	Note: It is allowed during 5 sec and four times during the service life
At landing with ballooning (free fall)	Mi-8…………..TBD Mi-17…………75% Mi-24…………75% Mi-35…………75%	
At failure of one engine	Mi-8…………..86% Mi-17…………75% Mi-24…………75% Mi-35…………80%	For Mi-36 80% is in very rare cases Note: It is allowed during 10 seconds and four times in service life
Max. Permissible MR rotational speed at all power conditions in emergency case	Mi-8…………..86% Mi-17…………75% Mi-24…………75% Mi-35…………80%	Note: 1/ The number of over speeding (108% or 105%) should not exceed two times during first over haul. 2/ It should not exceed 6 times during the service life. 3/ The deviation of each over speeding should not exceed 20sec or for Mi-8………5sec Mi-17…….20sec Mi-24………….20sec Mi-35…………20sec 4/ During engine failure of one engine, the second engine can operate in T.O. mode for not more than 1hr. After that the engine or main gear box Should be replaced.

3.13 Fuel regulating pump [16,17,18,19,20,21,22]

Pump-regulator NR-series unit is intended for fuel supply and automatic control of the engine TV3-117. It ensures:

- Fuel metering of engine during starting, acceleration and deceleration;
- Maintain the preset operation modes according to the turbo-compressor rotor speed and free turbine speed;
- Synchronizing air pressure behind compressors

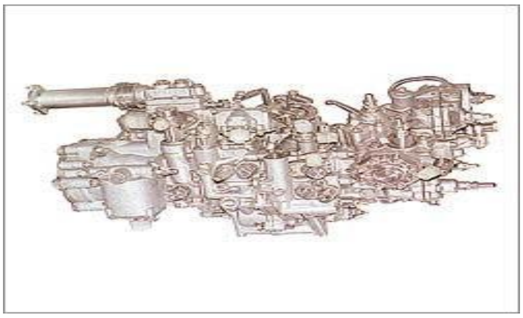

Fig. 13- Pump-regulator NR-3A

Table 17 Fuel regulating pump differences

Parameter	Data	Remark
Fuel regulating pump designation	Mi-8………….. HP-40BГ (HP-40BP) Mi-17………… HP-3MT Mi-24………… HP-3A Mi-35………… HP-3B	Simultaneous operation of two engines; ▪ Change of fuel feed as provided by the electronic regulator signs; ▪ Fuel distribution around the nozzles; ▪ Engine stop;

Type	Mi-8………….. plunger Mi-17………… plunger Mi-24………… plunger Mi-35………… plunger	▪ Control of compressor directional devices.

3.14 DC starting generator [16,17,18,19,20,21,22]

Table 18 DC starting generator differences

Parameter	**Data**	**Remark**
Designation	Mi-8………….. ГС-18МО or ГС-18ТО Mi-17………… not available Mi-24………….not available Mi-35………… not available	Note: DC starter generator is not found in 3nd series engines the reason is that they have AI-9V air starter but Mi-8 does not have it.
Quantity	Mi-8…………..1	
Sense of rotation	Mi-8…………..CCW	
Gear ratio	Mi-8…………..0.41	

315 Differentiating engine starting system [16, 17, 18, 19, 20, 21, 22]

It is used to spin up the gas generator rotor at starting to the required rotational speed and it starts the engine on ground as well as in the air. It is operated by the air supplied by АИ-9В in case of TV3 series engine and is mounted on the upper portion of the engine. It consists of air valve, control unit, turbine, reduction gear & air filter.

A. The auxiliary power plant (gas turbine engine)

Mi-8 ------------------- DC generator
Mi-17 ------------------ АИ-9В
Mi-24------------------ АИ-9В
Mi-35 ----------------- АИ-9В

B. Interchangeability of АИ-9В

Mi-8 with Mi-17, Mi-24, Mi-35…………….Mi-8 has not AI-9V
Mi-17 with Mi-24, Mi-35……………………interchangeable
Mi-24 with Mi-35……………………………interchangeable

C. Air starter

Mi-8…………………………………..null
Mi-17/Mi-24/Mi-35 …………………CB-78

3,16 Engine Operating Conditions & Parameters (at H=0, V=0) [16, 17, 18, 19, 20, 21, 22]

Factors to be considered when tabulating the data for engine operations are listed below. The limited observed speed, n_{obs} is indicated by the MR tachometer generator mounted on the MGB.

i. CTIGT is for Compressor Turbine Inlet Gas Temperature
ii. There is no cruise & cruise II modes for Mi-8
iii. 100% of compressor rotor rpm corresponds to
Mi-8 ………………….21200
Mi-17…………………19500
Mi-24…………………19500
Mi-35…………………19500
iv. 100% free turbine rpm corresponds to
Mi-8 ………………….12000
Mi-17…………………15000
Mi-24…………………15000
Mi-35…………………15000

3.17 Summary of operating parameters

Parameters	**Operating Conditions**								
	Mi-8				**TB3-117 (Mi-17, Mi-24, Mi-35)**				
	Take Off	**Maximum Continuous**	**Cruising**	**Idle**	**Take Off**	**Maximum Continuous**	**Cruise I**	**Cruise II**	**Idle**
CTIGT (Cº)	850	790	750	600	975	900	870	830	780
Max. permissible For CTIGT (Cº)	880*	860	810	TBD	990	955	910	870	TBD
Max. SFC (g/hphr)	275	295	310	100kg/hr	230	250	270	290	165 kg/hr max.
shaft power (hp)	1500_{-30}	1200_{-24}	1000_{-20}		2225-44	1700-34	1500-30	1200-24	200 max
Ngg (%)	98.5	96	94.5	+2	97.5 ±0.5	94.7±0.5	93.5± 0.5	91.5± 0.5	73+6
Ngg, max (%)	101	100	98	64-1	101	98	96	94	79
Nft (%)	101	98	96.5		98±1	100±2	100±2	100±2	65.5
Nmr (%)	93_{-1}	95±2	95±2	45±10	93±1	95±2	95±2	95±2	-
Oil temp. (Outlet) (Cº)	30 to125			40 to+125					
Fuel pressure (Pf) (kgf/cm^2)	60max	-	-	18 to 35					
Oil pressure (Po) (Kgf/cm^2)	3 to 4			2 to 4					
Max time of Continuous operation (mn)	6	60		20					

4. Conclusion

We conclude that the Isotov TV2 and TV3 or the second and third series engines are totally different in engine construction as well as performance. The TV3 Klimov engines have higher performance and capable of operating in higher terrains (Altitudes). Among the third series engines namely TV3-

117A, TV3-117V, TV3-117MT and TV3-117VM; the VM series engine is more modernized, high altitude engine and updated model of "A". Mostly the constructions of third series engine are similar.

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TV2-117A maintenance manual

TV2-117A Engine testing and operational manual

Mi-8 helicopter flight manual

TV3-117A maintenance manual

TV3-117A Engine testing and operational manual

Mi-17 helicopter flight manual

Mi-24D/Mi-35 helicopter flight manual